3-VRMS Audio Line Driver With Adjustable Gain

DESCRIPTION

The EUA6632 is a 3-Vrms audio line driver with adjustable gain. The EUA6632 is capable of driving 2 Vrms into a 10kΩ load with 3.3-V supply voltage. The device has differential inputs and uses external gain-setting resistors to support a gain range of ±1V/V to ±10V/V, and gain can be configured individually for each channel. The EUA6632 has built-in active-mute control for pop-free audio on/off control. The EUA6632 has an external under voltage detector that mutes the output when the power supply is removed, ensuring a pop free shutdown. Using the EUA6632 in audio products can reduce component count considerably compared to traditional methods of generating a 3-vrms output. The EUA6632 does not require a power supply greater than 3.3V to generate its 5.6-Vpp output, nor does it require a split-rail power supply. The EUA6632 integrates its own charge pump to generate a negative supply rail that provides a clean, pop-free ground-biased 3-Vrms output.

The EUA6632 is available in a 14-pin TSSOP.

FEATURES

- Supply Voltage 3V to 5V
- 2Vrms Into 10kΩ With 3.3V Supply
- Low THD+N<0.01% at 2Vrms Into 10kΩ
- High SNR>90dB
- 16Ω Output Load Compliant
- Differential Input and Single-Ended Output
- Adjustable Gain by External Gain-Setting Resistors
- Ground-Referenced Outputs Eliminate DC Blocking Capacitors
  - Reduce Board Area
  - Reduce Component Cost
  - Improve THD+N performance
  - No Degradation of Low Frequency Response Due to Output Capacitors
- Short-Circuit Protection
- Click and Pop-Reduction Circuitry
- External Under voltage Mute
- Active Mute Control for Pop-free Audio On/Off Control
- RoHS compliant and 100% lead(Pb)-free Halogen-Free

APPLICATIONS

- Set-Top Boxes
- Blue-ray Disc、DVD Players
- LCD and PDP TV
- Mini/Micro Combo Systems
- Sound Cards
- Laptops

Typical Application Circuit

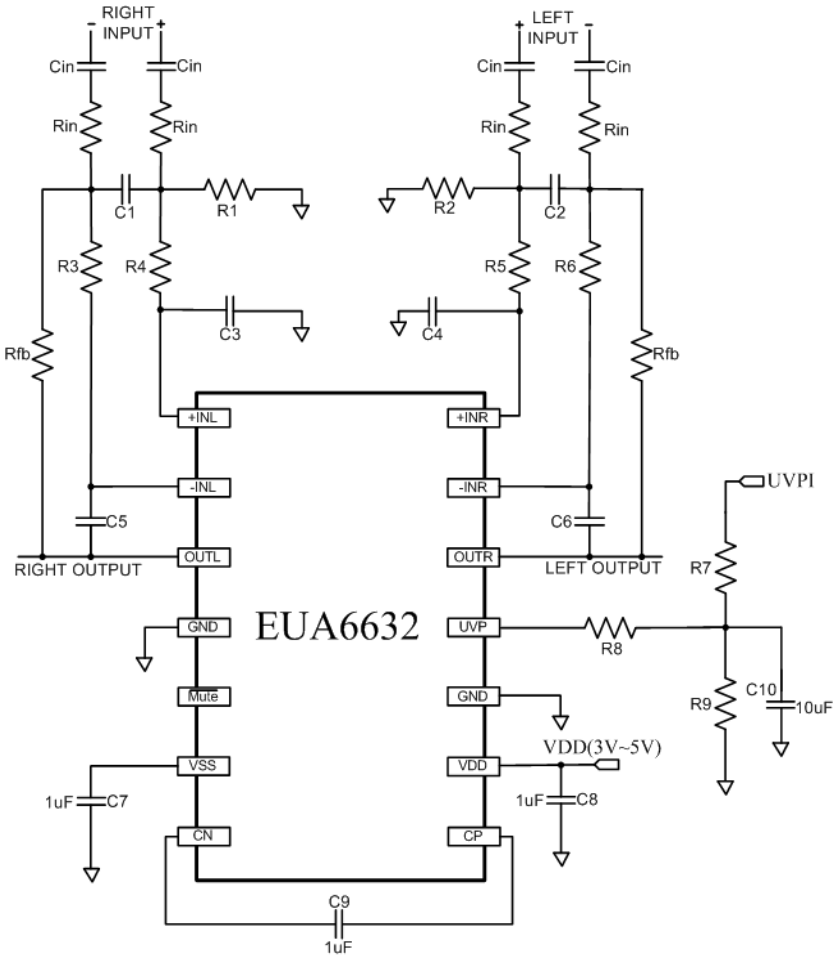
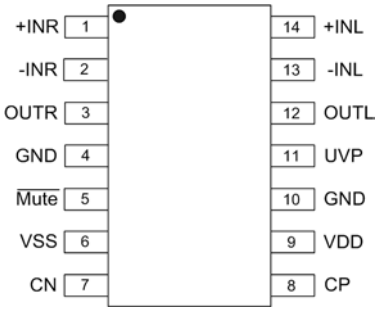


Figure 1. Typical Application Circuit

Pin Configurations

Package	Pin Configurations
TSSOP-14	

Pin Description

SYMBOL	PIN	I/O/P	DESCRIPTION
+INR	1	I	R-Channel Positive Input.
-INR	2	I	R-Channel Negative Input.
OUTR	3	O	R-Channel Output.
GND	4	P	Amplifier Ground.
MUTE	5	I	Mute, active-low
VSS	6	I	Charge Pump Output. Connect a 1uF ceramic capacitor to GND
CN	7	I/O	Flying capacitor Negative Terminal. Connect a 1uF ceramic capacitor from CP to CN.
CP	8	I/O	Flying capacitor Positive Terminal. Connect a 1uF ceramic capacitor from CP to CN.
VDD	9	P	Positive Power Supply Input. Bypass with a 1uF capacitor to GND.
GND	10	P	Amplifier Ground.
UVP	11	I	Under voltage protection
OUTL	12	O	L-Channel Output.
-INL	13	I	L-Channel Negative Input.
+INL	14	I	L-Channel Positive Input.

Ordering Information

Order Number	Package Type	Marking	Operating Temperature Range
EUA6632QIR1	TSSOP-14	xxxxx EUA6632	-40°C to 85°C

EUA6632 □ □ □ □

Lead Free Code
1: Lead Free 0: Lead

Packing
R: Tape & Reel

Operating temperature range
I: Industry Standard

Package Type
Q: TSSOP

Absolute Maximum Ratings

- Supply voltage, V_{DD} ---------- 3V to 5.5V
- Input voltage, V_I ---------- -0.3 V to V_{DD} +0.3V
- Storage temperature rang, T_{stg} ---------- -65°C to 150°C
- ESD Susceptibility ---------- 2kV
- Junction Temperature ---------- 150°C
- Thermal Resistance

  θ_{JC} (TSSOP) ---------- 32°C/W

  θ_{JA} (TSSOP) ---------- 137°C/W

Recommended Operating Conditions

	MIN	NOM	MAX	UNIT
Supply Voltage, V_{DD}	3		5.5	V
High-level input voltage, V_{IH}	1.55			V
Low-level input voltage, V_{IL}			0.5	
Operating free-air temperature, T_A	-40		85	°C

Electrical Characteristics

T_A=25°C,VDD=3.3V,Gain=-2V/V(unless otherwise noted)

Symbol	Parameter	Conditions	EUA6632			Unit
			Min.	Typ.	Max.	
V_{OS}	Output offset voltage	V_{DD}=3.3V		10		mV
PSRR	Power supply rejection ratio	f=1kHz,Vin=100mVpp		80		dB
V_{UVP_EX}	External UVP detect voltage			1.25		V
$V_{UVP\_EX\_SYS}$	External UVP detect voltage hysteresis current			5		uA
F_{OSC}	Charge pump switching frequency			350		kHz
I_{DD}	Supply Current	VDD=3.3V, No load, MUTE=VDD	5	14	25	mA
V_{OUT}	Output Voltage	RL=10kΩ, THD+N=1% , f=1kHz		2.3		Vrms
THD+N	Total Harmonic Distortion Plus Noise	RL=10kΩ, V_O=2Vrms, f=1kHz		0.008		%
Z_O	Output Impedance when muted	MUTE=GND		10		mΩ
	Input to Output attenuation when muted	MUTE=GND		80		dB
OT	Thermal Shutdown			150		℃
	Thermal Shutdown Hysteresis			20		
I_{LIMIT}	Current limit			250		mA

Operating Characteristics

T_A=25°C, Gain=-2V/V(unless otherwise noted)

Symbol	Parameter	Conditions	EUA6632			Unit
			Min.	Typ.	Max.	
P_O	Output power	V_{DD}=3.3V,THD+N=1%, f=1kHz,R_L=32Ω		60		mW
		V_{DD}=3.3V,THD+N=1%, f=1kHz,R_L=16Ω		45		mW
THD+N	Total harmonic distortion plus noise	V_{DD}=3.3V,P_O=10mW, R_L=32Ω, f=1kHz		0.03		%
		V_{DD}=3.3V,P_O=10mW, R_L=16Ω, f=1kHz		0.03		
SNR	Signal-to-noise ratio	f=1kHz, RL=10kΩ,V_O=1Vrms ,A-weighted		103		dB
Crosstalk		f=1kHz, RL=10kΩ, V_O=1Vrms		-110		dB

Block Diagram

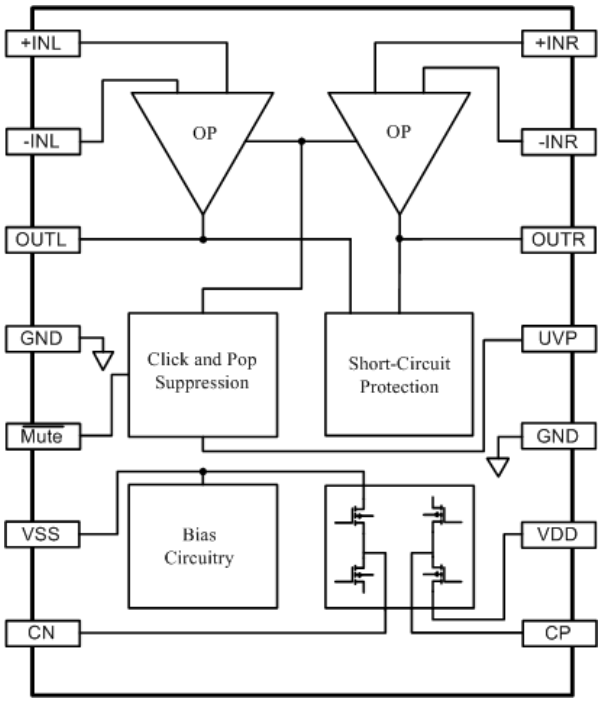


Figure 2. Functional Block Diagram

Operating Characteristics

VDD=3.3V, T_A=25℃, $C_{(PUMP)}$=$C_{(VSS)}$=1uF, C_{IN}=2.2 uF, R_{IN}=15kΩ, R_{FB}=30kΩ (unless otherwise noted)

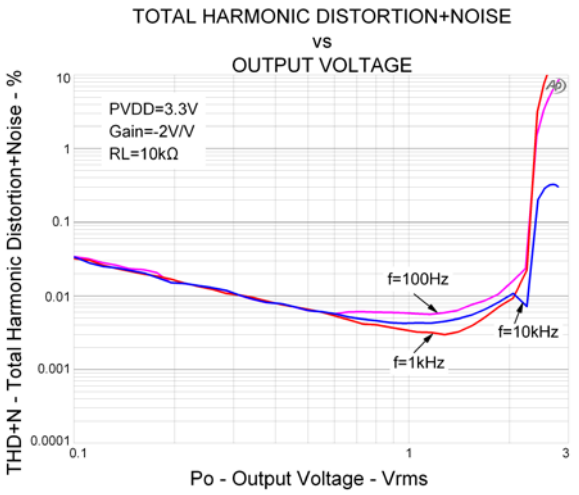


Figure 3

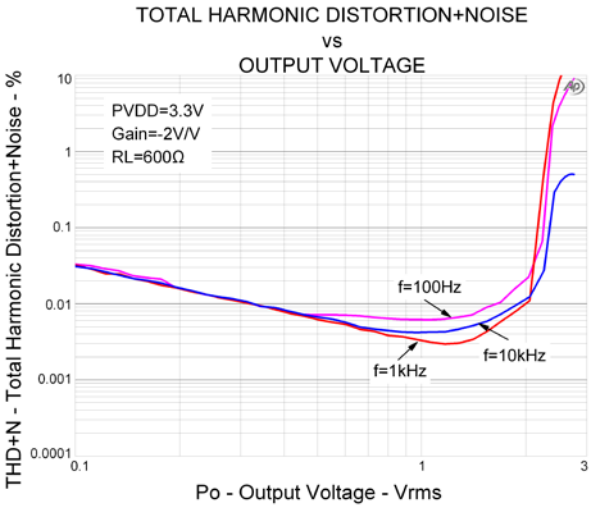


Figure 4

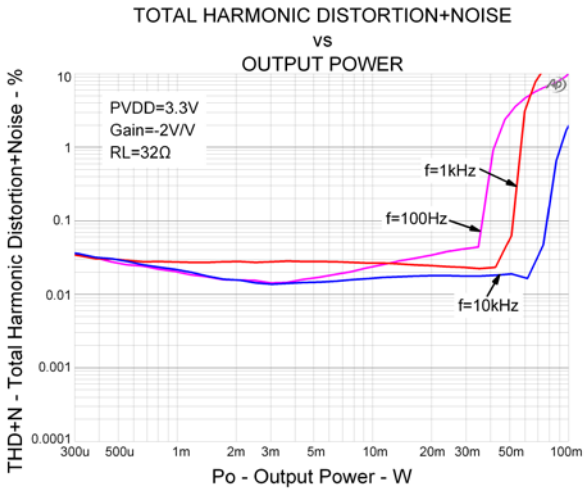


Figure 5

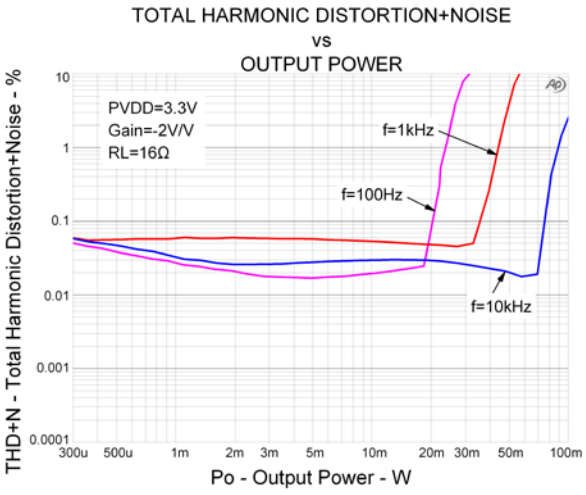


Figure 6

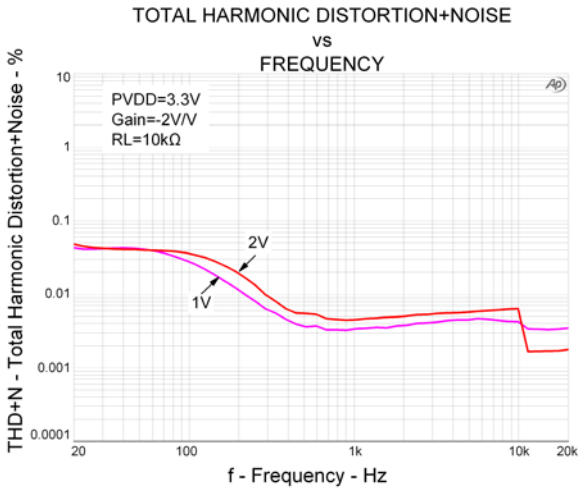


Figure 7

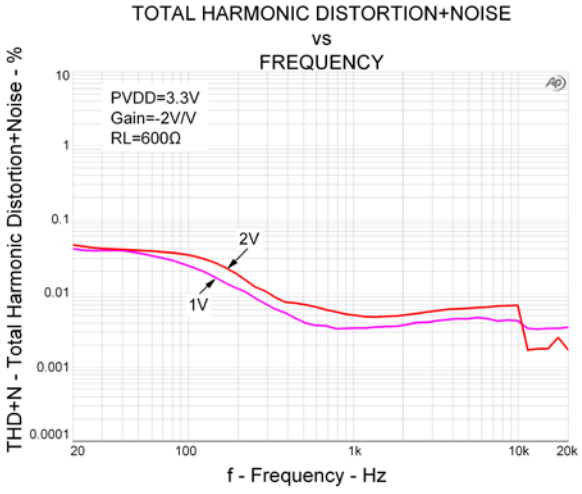


Figure 8

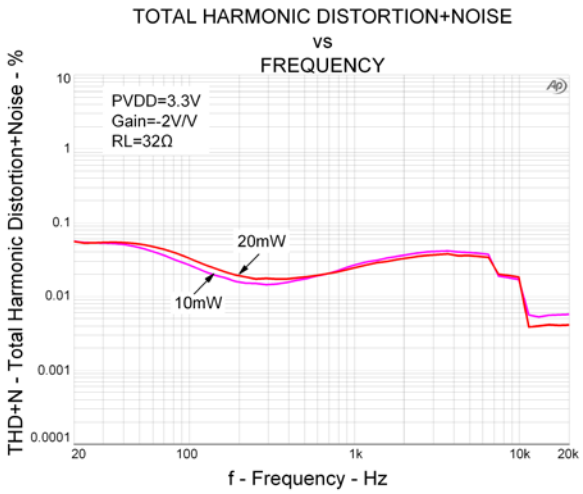


Figure 9

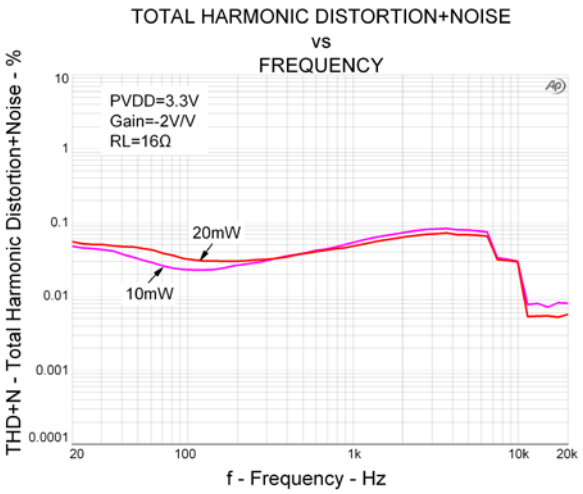


Figure 10

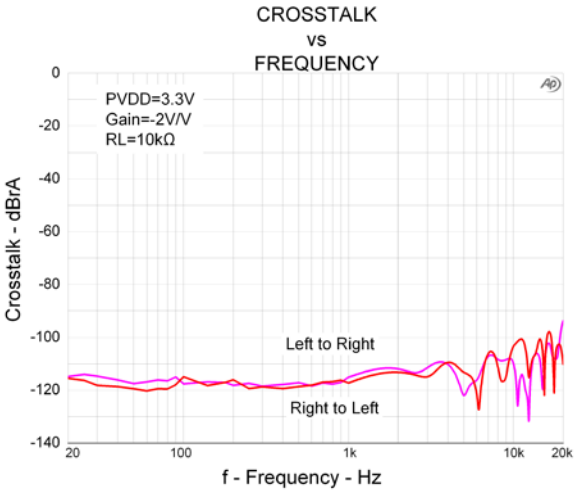


Figure 11

Application Information

Line Driver Amplifiers

A conventional inverting line-driver amplifier always requires an output dc-blocking capacitor. The top drawing in Figure 12 illustrates the conventional line-driver amplifier connection to the load and output signal. DC blocking capacitors are often large in value. The line load (typical resistive values of 16 Ω to 10 kΩ) combines with the dc blocking capacitors to form a high-pass filter. Equation 1 shows the relationship between the load impedance (R_L), the capacitor (C_O), and the cutoff frequency (f_c).

$$f_c = \frac{1}{2\pi R_L C_O} \quad (1)$$

C_O can be determined using Equation 2, where the load impedance and the cutoff frequency are known.

$$C_O = \frac{1}{2\pi R_L f_c} \quad (2)$$

If f_C is low, the capacitor must then have a large value because the load resistance is small. Large capacitance values require large package sizes. Large package sizes consume PCB area, stand high above the PCB, increase cost of assembly, and can reduce the fidelity of the audio output signal.

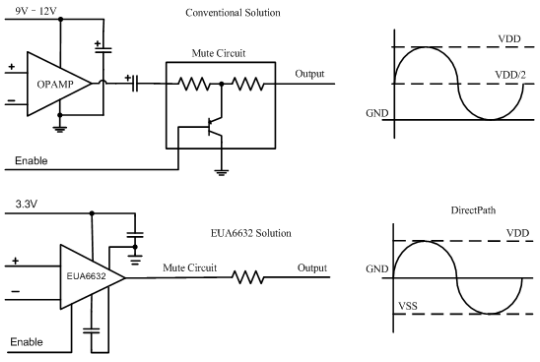


Figure 12.Conventional and DirectPath Line Drivers

The Direct Path amplifier architecture operates from a single supply but makes use of an internal charge pump to provide a negative voltage rail. Combining the user-provided positive rail and the negative rail generated by the IC, the device operates in what is effectively a split-supply mode. The output voltages are now centered at zero volts with the capability to swing to the positive rail or negative rail. Combining this with the built-in click and pop reduction circuit, the Direct Path amplifier requires no output dc blocking capacitors. The bottom block diagram and waveform of Figure 12 illustrate the ground-referenced line-driver architecture. This is the architecture of the EUA6632.

Charge-Pump Flying Capacitor and PVSS Capacitor

The charge-pump flying capacitor serves to transfer charge during the generation of the negative supply voltage. The PVSS capacitor must be at least equal to the charge-pump capacitor in order to allow maximum charge transfer. Low-ESR capacitors are an ideal selection, and a value of 1μF is typical. Capacitor values that are smaller than 1μF can be used, but the maximum output voltage may be reduced and the device may not operate to specifications. If the EUA6632 is used in highly noise-sensitive circuits, recommends adding a small LC filter on the VDD connection.

Decoupling Capacitors

The EUA6632 is a Direct Path line-driver amplifier that requires adequate power supply decoupling to ensure that the noise and total harmonic distortion (THD) are low. A good, low equivalent-series-resistance (ESR) ceramic capacitor, typically 1μF, placed as close as possible to the device VDD lead works best. Placing this decoupling capacitor close to the EUA6632 is important for the performance of the amplifier. For filtering lower-frequency noise signals, a 10μF or greater capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of this device.

Gain-Setting Resistor Ranges

The gain-setting resistors, R_{IN} and R_{FB}, must be chosen so that noise, stability, and input capacitor size of the EUA6632 are kept within acceptable limits. Voltage gain is defined as R_{FB} divided by R_{IN}.

Selecting values that are too low demands a large input ac-coupling capacitor, C_{IN}. Selecting values that are too high increases the noise of the amplifier. Table1 lists the recommended resistor values for different

inverting-input gain settings.

Table1 recommended resistor values

GAIN	R_{IN}	R_{FB}
-1V/V	10kΩ	10kΩ
-1.5 V/V	8kΩ	12kΩ
-2 V/V	15kΩ	30kΩ
-10 V/V	4.7kΩ	47kΩ

Input-Blocking Capacitors

DC input-blocking capacitors are required to be added in series with the audio signal into the input pins of the EUA6632. These capacitors block the dc portion of the audio source and allow the EUA6632 inputs to be properly biased to provide maximum performance.

These capacitors form a high-pass filter with the input resistor, RIN. The cutoff frequency is calculated using Equation 3. For this calculation, the capacitance used is the input-blocking capacitor, and the resistance is the input resistor chosen from Table 1; then the frequency and/or capacitance can be determined when one of the two values is given.

It is recommended to use electrolytic capacitors or high-voltage-rated capacitors as input blocking capacitors to ensure minimal variation in capacitance with input voltages. Such variation in capacitance with input voltages is commonly seen in ceramic capacitors and can increase low-frequency audio distortion.

$$f_{cIN} = \frac{1}{2\pi R_{IN} C_{IN}} \quad or \quad C_{IN} = \frac{1}{2\pi f_{cIN} R_{IN}} \qquad (3)$$

EUA6632 UVP Operation

External Under voltage Detection

External under voltage detection can be used to mute/shut down the EUA6632 before an input device can generate a pop.

The shutdown threshold at the UVP pin is 1.25 V. The user selects a resistor divider to obtain the shutdown threshold and hysteresis for the specific application. The thresholds can be determined as follows:

$V_{UVP} = (1.25 – 6\mu A \times R3) \times (R1 + R2) / R2$

Hysteresis = $5\mu A \times R3 \times (R1 + R2) / R2$

For example, to obtain V_{UVP} = 3.8 V and 1-V hysteresis, use R1 = 3kΩ, R2 = 1kΩ, and R3 = 50kΩ.

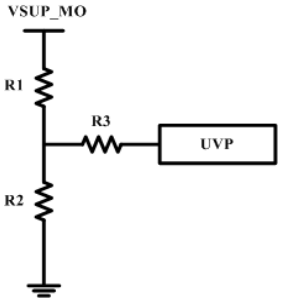


Figure 13. UVP Resistor Divider

Using the EUA6632 as a Second-Order Filter

Several audio DACs used today require an external low-pass filter to remove out-of-band noise. This is possible with the EUA6632, as it can be used like a standard operational amplifier. Several filter topologies can be implemented, both single-ended and differential. In Figure 14, multi-feedback (MFB) with differential input and single-ended input are shown.

An ac-coupling capacitor to remove dc content from the source is shown; it serves to block any dc content from the source and lowers the dc gain to 1, helping to reduce the output dc offset to a minimum.

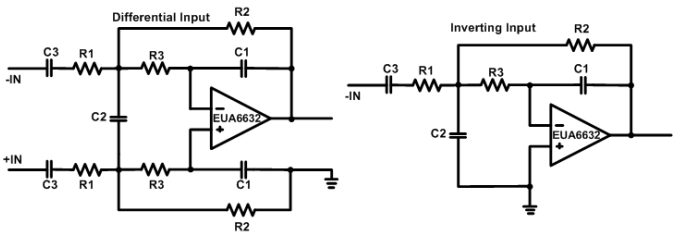


Figure 14. Second-Order Active Low-Pass Filter

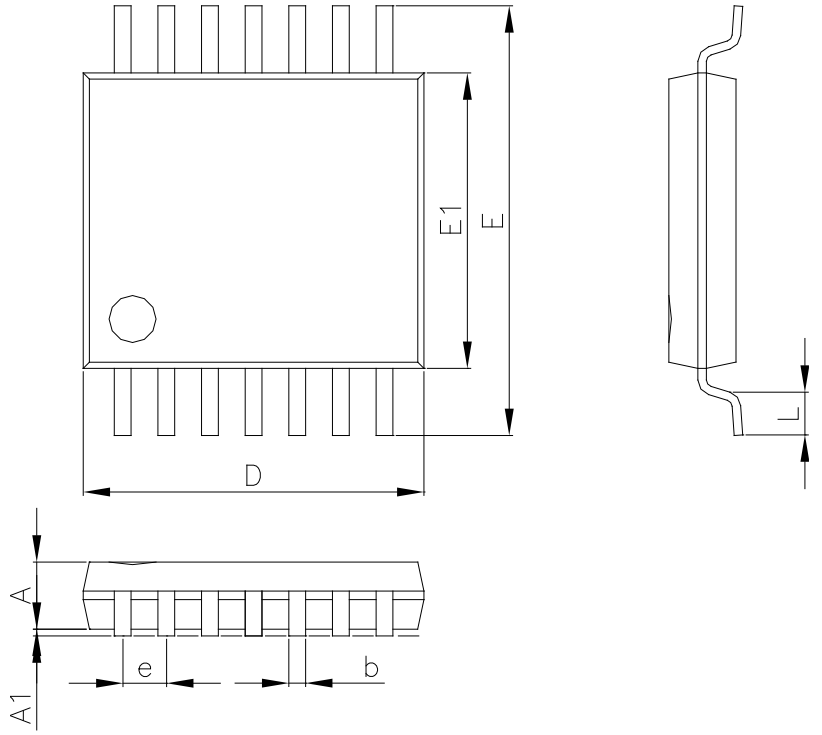
The resistor values should have a low value for obtaining low noise, but should also have a high enough value to get a small-size ac-coupling capacitor. With the proposed values of R1=15kΩ, R2=30kΩ, and R3=43kΩ.

Mute Mode

The EUA6632 can be muted using the low-active Mute pin (pin 5). The click-and-pop suppression capacity ensures that when the mute mode is used, it does not generate an additional click or pop.

Package Information

TSSOP-14L



Note: Package outline drawing is for reference only.

SYMBOLS	MILLIMETERS			INCHES		
	MIN.	Normal	MAX.	MIN.	Normal	MAX.
A	-	-	1.20	-	-	0.047
A1	0.00	-	0.15	0.000	-	0.006
b	0.19	-	0.30	0.007	-	0.012
E1	4.30	4.40	4.50	0.169	0.173	0.177
D	4.85	5.00	5.15	0.191	0.197	0.203
E	6.20	6.40	6.60	0.244	0.252	0.260
e	0.65 REF			0.026 REF		
L	0.45	0.60	0.75	0.018	0.024	0.030